direction of the light. Because of the circularly symmetric nature of the diverging light beam, the transverse polarization generates a differential absorption. For example, if the atomic polarization has a component along the x direction, light that has a component in the x direction will see reduced absorption, while light that has a component in the −x direction will see increased absorption. As the atomic polarization vector precesses, therefore the spatial profile of the diverging light field will be modified accordingly.

FIG. **2** illustrates a schematic of the operation of a diverging beam magnetometer **100** in accordance with one embodiment of the present invention. The instrument is placed in the vicinity of the DC magnetic field to be sensed, B_0, **110**. Atoms, **120** are polarized along the average direction of propagation of the incident light field, **130**. RF coils, **140**, generate an oscillating magnetic field at the Larmor frequency of atoms in a direction perpendicular to the magnetic field. This causes the atomic polarization to precess at the drive frequency about the magnetic field B_o, as shown by the precessing vector, **150**. The transverse component of the atomic polarization, **160**, is detected by monitoring the absorption of the edges of the diverging light beam, **170**. By subtracting the signals coming from opposite sides of the light beam, the magnitude of the precessing transverse atomic polarization can be determined.

FIG. **3** illustrates a schematic of the operation of a diverging beam gyroscope **200** in accordance with one embodiment of the present invention. The instrument is placed in a well-controlled, known, uniform magnetic field, B_0, **205**. The spin of alkali atoms (such as ^{133}Cs, ^{87}Rb, or ^{39}K), **210** is polarized via optical pumping with a component along the average direction of propagation of the incident light field, **215**. The spin of the nuclei of noble gas atoms, **220** (^{129}Xe, ^{3}He or equivalent) is polarized with a component along the average direction of propagation of the incident light field via spin exchange collisions with the alkali atoms. One set of RF coils, **225**, generate an oscillating magnetic field, □B_1, **230**, in a direction perpendicular to the magnetic field, B_o, **205** at the Larmor frequency of noble gas atoms **220**. This causes the nuclear polarization to precess at the drive frequency of the RF coils **225** about the magnetic field B_0 **205**. A second AC magnetic field □B_2 **245** is applied parallel to the static field B_o **205**, at the Larmor frequency of the alkali atoms **210**. This field causes the alkali atom spins to precess, **250**, about the total field created by the static field, B_o **205**, and the precessing polarization of the noble gas nuclei, **220**. The transverse component of the atomic polarization is detected by monitoring the absorption of the edges of the diverging light beam, **255**. By subtracting the signals, **260**, coming from opposite sides of the light beam, the magnitude of the precessing transverse atomic polarization, and in turn the Larmor frequency of both the alkali and the noble gas species. The angular rate of the vessel, can be determined from the induced shift in the measured noble gas Larmor frequency.

FIG. **4** illustrates a schematic of an implementation of the diverging beam magnetometer or gyroscope **300** in accordance with one embodiment of the present invention. In this implementation, the diverging components of the laser beam **310** are reflected by angled walls inside the alkali vapor cell **330** to form counter-propagation probe beams **340**. These beams are reflected a second time off the opposite wall and the power is detected by photodiodes **350** placed on the base plate **360** with the laser **370**.

FIG. **5** illustrates a schematic of the basic operation of a co-magnetometer nuclear magnetic resonance ("NMR") gyroscope as a co-magnetometer. The diverging light beam **410** polarized the alkali species **420** in the nominal direction of the light propagation. The noble gas species **430** is subsequently polarized via spin-exchange collisions with the alkali atoms. A longitudinal magnetic field B_0 **440** is applied with a magnitude that largely cancels the field due to the noble gas as seen by the alkali atoms. Under rotation, the noble gas spins **430** become misaligned with the longitudinal field **440** and the spin orientation rotates slightly about the component of the longitudinal field **440** perpendicular to the noble gas spin orientation. The rotation of the noble gas spin **430** causes a small transverse field B_{tran} **450** seen by the alkali atoms **420**. This transverse component **550** causes the orientation of the alkali species, **460**, to change slightly. The orientation change of the alkali species causes a differential absorption of the counter-propagating light fields **470**. The difference in absorption is measured by two photodetectors **480**. The difference in the signals measured by the photodetectors **480** is proportional to the instrument rotation rate.

FIG. **6** illustrates a schematic of a cross-sectional view of a compact nuclear magnetic gyroscope **500** ("NMRG") in accordance with one embodiment of the present invention. A multilayer magnetic shield **510** (here 3 layers) is used to suppress the external magnetic field **520** (e.g., Earth's field, fields created by adjacent electrical components, and other environmental fields) by over six orders of magnitude. Inside the shields, a set of 3-axis coils **530** are used to create a very precise static magnetic field B_o. Additionally, the coils **530** are also used to compensate for residual magnetic fields (external or internal to the shields) that may exist in the area of the NMR cell **540**. The light from the laser on the base-plate is circularly polarized by a wave plate and transmitted through the NMR cell **540**. The light is then reflected off the angled cell walls back onto photodiodes on the base plate **550**. Two small flex circuits **570** provide paths for electrical signals for both the base plate **550** and the 3-axis coils **530** to flow between the interior of the shield **510** and the exterior.

FIG. **7**(*a*) and FIG. **7**(*b*) illustrate a schematic of the exterior **600** and cross-sectional view of magnetic shields **610** in accordance with one embodiment of the present invention. While a 3-layer shield is shown for illustrative purposes, the number of layers will vary depending on the desired shielding factor and the particular application. The shields may be machined and welded from a high-permeability material such as mumetal. The nuclear magnetic resonance gyroscope is to be positioned at the center of the shields and the flex circuits from the coils and the base plate is to be threaded through the holes **620** of the shield caps **630**. The spacers **640** that are used to separate the shield layers are machined from a nonmagnetic material.

FIG. **8**(*a*) and FIG. **8**(*b*) illustrate a schematic of a two-layer flex circuit fabricated on a planar substrate and a flex circuit wrapped around a cylindrical holder to form a set of three-axis coils **700** in accordance with one embodiment of the present invention. A set of three-axis coils **700** are used to generate the static and oscillating magnetic fields (B_0 **205** □B_1 **230** and □B_2 **245** in FIG. **3**) as well as for compensation of residual fields. The coils **710** are fabricated as highly conductive traces (e.g. metal) on a two-layer flexible planar substrate **720**, such as polyimide. The planar substrate is then wrapped around a machined cylindrical holder **730** and the conductive pads on two opposite sides of the substrate are brought in contact and affixed to each other (e.g. soldered) to form a set of three-axis coils **700**. The tail end of the flex of the coils **740** contains bonding pads, which allows the coils **700** to be connected to external circuitry once the flex has been threaded through the shields. Once assembled, both the length and the diameter of the coil structure are on the order of 2 to 10 millimeters. The coil for the longitudinal magnetic